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Technical specifications

Équipement radioélectrique du Chemin de fer

Spécifications techniques

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Contents

Summary	1
1 - General.....	2
2 - Characteristics of the radio links	3
3 - Regulations applicable to the radio equipment	4
3.1 - Regulations governing radio equipment utilisation and interference reduction	4
3.2 - Regulations for personnel protection	4
3.3 - Regulations governing rail applications	4
4 - Conditions specific to the railway environment	5
4.1 - Supply voltage	5
4.1.1 - Fixed stations	5
4.1.2 - Vehicle-mounted sets	5
4.1.3 - Portable sets	5
4.2 - Ambient temperature	6
4.2.1 - Fixed stations	6
4.2.2 - Vehicle-mounted sets	6
4.2.3 - Portable sets	6
4.3 - Vibrations	7
4.3.1 - Fixed stations	7
4.3.2 - Vehicle-mounted sets	7
4.3.3 - Portable sets	7
4.4 - Shocks	7
4.4.1 - Fixed stations	7
4.4.2 - Vehicle-mounted sets	7
4.4.3 - Portable sets	7
4.5 - Protection against dust, water and humidity	7
4.5.1 - Dust.....	7
4.5.2 - Water	8
4.5.3 - Humidity	8
4.5.4 - Degrees of protection.....	8
4.6 - Protection against intermodulation effects.....	8

5 - Type testing by the National Post or Telecommunications Administration.....	9
6 - Aptitude Testing by the railway	10
6.1 - Operational tests under extreme supply voltage and within temperature range 1	10
6.2 - Operational tests within temperature range 2.....	10
6.3 - Tests within temperature range 3	10
6.4 - Vibration test.....	10
6.4.1 - Determination of resonance frequencies	10
6.4.2 - Sustained vibration test.....	11
6.5 - Shock test.....	11
6.5.1 - Fixed stations	11
6.5.2 - Vehicle-mounted sets	11
6.5.3 - Portable sets	11
6.6 - Checking the battery holder in portable sets	11
6.7 - Checking the degree of protection.....	11
6.8 - Checking radio characteristics of receivers	12
6.9 - Operational test	12
7 - Reliability of radio sets	13
7.1 - General	13
7.2 - Increase in reliability - accelerated ageing.....	13
7.3 - Temperature test	13
7.4 - Shock and vibration test	14
7.5 - Permanent operation	14
7.6 - Final check after accelerated ageing	14
Bibliography	15

Summary

This leaflet describes the technical rules governing analogue radio equipment in the rail sector.

The leaflet does not detail the specific conditions for digital radio operations nor technical regulations governing GSM-R.

The leaflet describes first of all the general framework conditions and refers to national regulations in force and corresponding national and international standards. The different characteristics of the radio links are then listed.

The next section refers to regulations governing radio equipment utilisation and interference reduction. Regulations for the protection of personnel from dangerous electrical currents as well as regulations governing rail applications are also mentioned.

Conditions specific to the railway environment, such as supply voltage for fixed stations, vehicle-mounted sets as well as portable sets and the required temperature ranges, are listed and explained.

Chapter 3 goes on to describe other environmental conditions such as vibrations, shocks, dust, water, humidity and recommends corresponding degrees of protection.

A further paragraph defines a minimum performance rating to protect against intermodulation effects.

The leaflet then looks at type testing as carried out by the national regulatory authorities as well as aptitude testing by the railways. This chapter gives details of operational tests under extreme supply voltage and within different predefined temperature ranges.

Further parameters for vibrations and shocks are also mentioned, such as tests for checking the different degrees of protection. Before the final operational test is mentioned, values are defined for radio-electric characteristics.

Chapter 6 describes the reliability of the radio sets, e.g. MTBF, accelerated ageing, temperature test, shock and vibration test and minimum values as well as permanent testing of sets and equipment.

The test programme ends with a final check after accelerated ageing.

As stated above, digital radio equipment is not covered by this leaflet. As such, an additional leaflet describing the same requirements for this type of equipment will be necessary.

1 - General

The use of radio communications by the railways is covered by *UIC Leaflet 750* (see Bibliography - page 15).

The present leaflet:

- provides recommendations and technical specifications for radio equipment for land mobile services,
- describes the environmental conditions in which radio equipment has to operate on the railways,
- recommends additional checks on the radio sets and equipment to ensure that they are suitable for railway service.

As far as the railway environment is concerned, only typical values are indicated which could apply to most radio equipment. Values which are encountered only rarely or extreme typical values (for example vibrations on a tamping machine) are not included in the leaflet. The railways should stipulate these in each specific case.

This leaflet refers to the following recommendations and provisions:

- National regulations of the Post and Telecommunications Administrations for mobile radio equipment;
- IEC (International Electrotechnical Commission) - Publications 364-4-41, 529 and 571;
- National standards corresponding to these IEC Publications.

2 - Characteristics of the radio links

- Communication modes: speech and data, either separately or combined.
- Traffic modes: simplex with one or two frequencies, duplex.
- Modulations: frequency, phase.
- Communication channel:
 - analog "speech" channel,
 - bandwidth:
 - approximately 300 3000 Hz for channel spacing of ≥ 20 KHz;
 - approximately 300 2500 Hz for channel spacing of < 20 kHz.

3 - Regulations applicable to the radio equipment

3.1 - Regulations governing radio equipment utilisation and interference reduction

Technical characteristics for mobile radio equipment are defined in the regulations of the National Post or Telecommunications Administrations.

The purpose of these regulations is to ensure economic operation of the frequency spectrum by a maximum number of users, by limiting interference and guaranteeing the quality and stability of radio links.

Approval of the standard equipment by the National Post or Telecommunications Administration (see point 5 - page 9) shall be proof that the radio system complies with these regulations.

3.2 - Regulations for personnel protection

The protection of personnel from dangerous electrical currents must be guaranteed by applying appropriate measures with respect to radio equipment in accordance with national standards, failing which IEC Publication 364-4-41 should be consulted.

3.3 - Regulations governing rail applications

3.3.1 - The typical values for temperature, vibrations, shock, humidity and dust, which occur in rail traffic, are only taken into consideration partly or not at all in the regulations referred to in point 3.1.

Each railway should therefore stipulate, for its radio equipment, additional provisions specific to the railway environment in accordance with point 4 - page 5.

Each railway should check that radio equipment is suitable for railway service by aptitude testing in accordance with point 5.

3.3.2 - To improve reliability on entry into service, it is recommended that the radio equipment be tested in accordance with point 7 - page 13.

4 - Conditions specific to the railway environment

4.1 - Supply voltage

4.1.1 - Fixed stations

Voltage: 110 V, 220 V \pm 10%¹, 50 Hz \pm 1Hz.
12 V =, 24 V =, 48 V = \pm 15%.

4.1.2 - Vehicle-mounted sets

Nominal voltage variations from 90% to 130% should be taken as extreme test conditions.

Nominal supply voltage: 12 V =.

If the vehicle-mounted set is to be supplied from the vehicle battery, with a nominal supply voltage (U_N) of 24 V, 48 V, 72 V or 110 V (which may vary between 0,7 U_N and 1,25 U_N in accordance with IEC Publication 571), a voltage converter must be provided so that the voltage can be reduced or regulated.

In many cases, railway-vehicle batteries are not earthed. In the case of vehicle-mounted sets on the other hand, the "negative" of the supply voltage is generally connected to the vehicle earth. Where applicable there should be galvanic insulation between battery potential and radio equipment potential.

The railways shall stipulate their own regulations for supply, depending on the type of battery used and the existing interference voltages. When such directives do not exist, railways shall apply the regulations laid down in IEC Publication 571.

4.1.3 - Portable sets

The supply source consists of a battery housed in the casing of the set or temporarily connected to it. The capacity of the battery must allow for continuous operation of the radio during 8 hours under the following minimum conditions:

- transmission: 10% of the time,
- reception: 20% of the time,
- stand-by: 70% of the time

within a temperature range of - 15 °C and + 40 °C.

The radio equipment, and the battery during charging, must be protected against polarity inversion.

1. In special cases: + 10%/- 15% (e.g. distance from source).

4.2 - Ambient temperature

A distinction is made between the following temperature ranges in the immediate vicinity of equipment:

- range 1: where the equipment retains its nominal characteristics which may nevertheless vary within permitted limits;
- range 2: where the equipment remains operational, but the values measured may slightly exceed the permissible limits. The battery capacity may be reduced;
- range 3: where the equipment is only partly operational or not at all. The permitted limits are widely exceeded, but no irreversible change in the characteristics or damage to components occurs (except perhaps to batteries).

For a country with a temperate climate and average altitude, the following values are recommended.

4.2.1 - Fixed stations

- range 1: - 10 °C to + 55 °C¹;
- range 2: - 20 °C to + 60 °C¹;
- range 3: - 25 °C to + 65 °C.

4.2.2 - Vehicle-mounted sets

- range 1: - 20 °C to + 55 °C;
- range 2: - 25 °C to + 70 °C¹ (in accordance with IEC Publication 571);
- range 3: - 30 °C to + 70 °C.

4.2.3 - Portable sets

- range 1: - 20 °C to + 55 °C;
- range 2: - 25 °C to + 60 °C;
- range 3: - 30 °C to + 65 °C.

1. If the margins stipulated are more restrictive, the railway must provide premises with corresponding thermal insulation.

4.3 - Vibrations

4.3.1 - Fixed stations

If a fixed station is situated in the immediate proximity of the track, it may be subject to the following vibrations:

- vertical vibrations with maximum acceleration of 5 m/s^2 , within the frequency band 1 Hz to 150 Hz. These extreme values are brought about by train speeds of up to 250 km/h if the subsoil is rocky or marshy. The mean values are about 2 m/s^2 within the 30 Hz to 80 Hz frequency band;
- horizontal vibrations attaining the above values occur on the walls of tunnels.

4.3.2 - Vehicle-mounted sets

IEC Publication 571 defines the characteristics of vibrations.

4.3.3 - Portable sets

The following values should be assumed:

permanent sinusoidal vibrations at frequencies between 10 Hz and 60 Hz with maximum amplitude of 0,3 mm - which corresponds to a maximum acceleration of $1,2 \text{ m/s}^2$ to 43 m/s^2 .

4.4 - Shocks

4.4.1 - Fixed stations

No specific conditions.

4.4.2 - Vehicle-mounted sets

IEC Publication 571 defines the shock characteristics. However, it is recommended that the following higher maximum acceleration value of 50 m/s^2 in three-dimensions be used.

4.4.3 - Portable sets

Free falling of the set from a height of about 1 m onto a solid surface.

4.5 - Protection against dust, water and humidity

4.5.1 - Dust

In the vicinity of the railway, dust contains metal particles. All sets should therefore be protected against dust deposits.

4.5.2 - Water

Fixed stations or vehicle-mounted sets are generally protected from water. In certain cases only (on the walls of tunnels or in vehicle-washing plants, for example), the sets may be exposed to water spray. Portable sets are always exposed to rain.

4.5.3 - Humidity

In railway environments the relative humidity may reach 100%. Vehicle-mounted and portable sets may be subject to condensation, depending on the climate.

4.5.4 - Degrees of protection

The following degrees of protection, corresponding to IEC Publication 529, are therefore recommended:

- fixed stations or vehicle-mounted sets: generally speaking, IP 50; in specific cases: IP 51 to IP 54 depending on the site,
- portable sets: IP 54.

4.6 - Protection against intermodulation effects

In large railway centres, the concentration of radio installations and the allocation to these of several adjacent channels, increase the risk of intermodulation effects considerably.

It is therefore necessary to adopt a protection ratio of at least 75 dB in the receiver.

5 - Type testing by the National Post or Telecommunications Administration

This is carried out in each country, at the request of the manufacturer, on one or several specimens from a given model, by the National Post or Telecommunications Administration in accordance with the national regulations.

If the test is conclusive, a certificate is supplied to the manufacturer, which authorises radio traffic using equipment of the type tested in the country in question. This certificate is essential for the use of sets in rail traffic.

6 - Aptitude Testing by the railway

In view of the cost, it is recommended that testing be limited to a few specimens.

The tests can be carried out by the railway itself, by a neutral inspection body or by the manufacturer at the request of the railway.

Operational tests shall be performed in accordance with national regulations. Unless otherwise specified, these tests shall cover the three types of equipment: fixed stations, vehicle-mounted sets, portable sets. The following procedures should be adopted:

6.1 - Operational tests under extreme supply voltage and within temperature range 1

These tests, carried out with an extreme supply voltage (see point 4.1 - page 5) and within temperature range 1 (see point 4.2 - page 6) in an atmosphere with average humidity (see point 4.5 - page 7), may be replaced by the Post or Telecommunications Administration approval certificate, provided that the values in point 4 - page 5 are covered by the national regulations.

6.2 - Operational tests within temperature range 2

The equipment is brought to the extreme lower and upper temperatures in range 2 as indicated in point 4.2. When it has reached thermal equilibrium, the supply voltage is switched on and the characteristics liable to be affected¹ are measured.

6.3 - Tests within temperature range 3

The equipment (less battery) is brought to the extreme lower and upper temperatures in range 3 as indicated in point 4.2. After reaching thermal equilibrium, the equipment is maintained at this temperature for one hour.

6.4 - Vibration test

The vibration test is carried out in 3 dimensions in accordance with IEC Publication 571.

6.4.1 - Determination of resonance frequencies

To detect the presence of critical resonance frequencies, the sinusoidal vibration is varied by one octave per minute (modification in relation to IEC Publication 571) within the range from 1 to 100 Hz. Maximum acceleration should be 10 m/s^2 . The amplitude of vibration "a" is a function of the frequency, and attains, for this particular acceleration, the following values in mm:

- $a = 25/f$ between 1 Hz and 10 Hz,
- $a = 250/f^2$ between 10 Hz and 100 Hz.

1. The characteristics liable to be affected are selected in the light of experience.

6.4.2 - Sustained vibration test

The fixed station is subjected to undamped vibration for at least 3 minutes, vehicle-mounted and portable equipment for at least 15 minutes:

- either at the critical resonance frequencies, determined by the test in accordance with point 6.4.1 - page 10,
- or at a frequency of 10 Hz, if no resonance has been detected.

In both cases the amplitude of the sinusoidal vibration should reach the value to be determined in accordance with point 6.4.1.

This test should be carried out with the equipment operating under nominal supply voltage.

6.5 - Shock test

6.5.1 - Fixed stations

Not applicable.

6.5.2 - Vehicle-mounted sets

The test is carried out in 3 dimensions in accordance with the method defined in IEC Publication 571.

For 2 minutes, sinusoidal vibrations are applied at 50 Hz and with a maximum acceleration of 30 m/s^2 (amplitude $a = 0,3 \text{ mm}$), with the equipment switched on and supplied at its nominal power.

However it is recommended that the equipment undergo harsher testing conditions in 3 dimensions, based on a maximum acceleration of 50 m/s^2 (amplitude $a = 0,5 \text{ mm}$).

6.5.3 - Portable sets

The test is carried out by allowing the set without its protective case to fall freely, in each of its three axes, from an average height of 90 cm, onto a horizontal surface of 20 cm-thick hardwood resting on a concrete base.

The set should not be allowed to fall on the side on which the controls are situated.

6.6 - Checking the battery holder in portable sets

The battery should be removed and inserted 5 000 times using a sample set. There must be no deterioration in the electrical and mechanical functioning of the set after these tests.

6.7 - Checking the degree of protection

The test specified in IEC Publication 529 is recommended when applying degree of protection IP 53 or IP 54.

6.8 - Checking radio characteristics of receivers

It is recommended that the 75 dB protection ratio against intermodulation effects, defined in point 4.6 - page 8, be tested under the following conditions:

- Maximum usable sensitivity better than 1 μ V e.m.f. for a SINAD signal-to-noise ratio of 20 dB;
- ambient temperature of 20 °C;
- nominal supply voltage.

6.9 - Operational test

The success of the tests carried out in accordance with point 6.2 - page 10 to 6.7 - page 11 shall be verified by a final operational test under normal conditions in accordance with national regulations.

7 - Reliability of radio sets

7.1 - General

If the failure rate of a set is apportioned in relation to the period of actual operation during its service life, we obtain a rounded curve with a higher failure rate at the beginning and end of the service life. The height of the flattened central part of the curve represents the permissible failure rate, namely the inverse value of the MTBF¹ desired.

For satisfactory operation of the sets, the following MTBF values related to the operating time are recommended:

- lineside sets \geq 20 000 h,
- keyboards \geq 17 000 h,
- vehicle-mounted sets \geq 5000 h (including lamps, handset, connecting flex),
- portable sets \geq 2000 h.

7.2 - Increase in reliability - accelerated ageing

If a railway demands more reliability for its sets, it must stipulate a value to be attained for the MTBF, or the inverse value (permissible mean failure rate) which it desires, and agree with the manufacturer on stricter test conditions for the mass-production tests (accelerated ageing) on all the sets.

Accelerated ageing makes it possible to obtain a lower failure rate in the central part of the rounded curve (see first paragraph of the point 7.1) from the beginning of the service life of a set.

7.3 - Temperature test

All the sets (except for the batteries) in a group are coded down or heated up to the temperature limits in range 3 and maintained at this temperature for at least 5 h after reaching their thermal equilibrium.

If the installation to be tested is too large or cumbersome, the various sub-assemblies can be subjected to the temperature tests before final assembly.

1. MTBF = Mean Time Between two Failures.

7.4 - Shock and vibration test

All the sets in a group are shaken in at least two dimensions¹ for 5 minutes each time, in the form of sinusoidal vibrations of 50 Hz. The maximum acceleration is:

- for fixed stations: 10 m/s² (amplitude "a" = 0,1 mm),
- for vehicle-mounted sets or portable sets: 50 m/s² (amplitude "a" = 0,5 mm).

In the third space dimension, this test should be carried out as a random check on at least 10% of all sets.

In the case of sets which are too large or cumbersome, the various sub-assemblies can be subjected to the tests in question before final assembly.

7.5 - Permanent operation

All the sets in a group must be kept switched on for at least 5 days, at the ambient temperature corresponding to the upper limit of range 1 (see point 4.2 - page 6).

During this period, the temperature-sensitive values² should be measured, by random check on at least 10% of the sets.

7.6 - Final check after accelerated ageing

Following accelerated ageing, there must be no doubt as to the satisfactory functioning and constant nature of the values of all the sets.

If, in the course of manufacture, the manufacturer has already carried out a check on the equipment before accelerated ageing, it is sufficient to verify the functioning of the equipment and the main values².

Otherwise, the manufacturer's complete final inspection should be carried out, in accordance with the agreed inspection programme, after accelerated ageing.

1. These directions are to be chosen in relation to the stresses on the installed sets.
2. These values are to be determined on the basis of experience.

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